

**U.S. National Work Group Meeting
for the
Development of Commercial Hydrogen Measurement Standards**

March 4-6, 2008
California Fuel Cell Partnership (CaFCP)
West Sacramento, California

AGENDA

This meeting is sponsored by the U.S. Department of Energy and U.S. Department of Commerce's National Institute of Standards and Technology.

Purpose: The U.S. National Work Group (USNWG) is meeting to continue its work to promote the establishment of a comprehensive set of (1) design, accuracy, installation, use, and method of sale requirements, (2) test procedures, and (3) quality standards for equipment used in hydrogen measurements for vehicle and other refueling applications.

ATTACHMENTS:

- Appendix A** Summary of the October 2007 USNWG Meeting
- Appendix B** USNWG Guidelines (Available March 4, 2008)
- Appendix C** Draft 2.1 of NIST Handbook 44 Gas Meters Code
- Appendix D** Comments on the 2nd Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (27 Sept2007) – Buttler (Micro Motion)
- Appendix E** Comments on 2nd Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (03Oct07) – Cohen (Air Products and Chemicals, Inc.)
- Appendix F** OIML R 81 "Dynamic Measuring Devices and Systems for Cryogenics Liquids"
- Appendix G** OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles"
- Appendix H** California Division of Measurement Standards Proposal for an Interim Specification for Hydrogen Fuel

AGENDA – DAY 1

DEVICE STANDARDS AND TEST PROCEDURES MEETING

Tuesday March 4, 2008, 8:30 a.m. – 5:00 p.m. (PT)
California Fuel Cell Partnership, 3300 Industrial Blvd., Dr. Lloyd Conference Room
West Sacramento, CA 95691
Moderator – Juana Williams (NIST)

- 8:30 - 9:00 **(1) Welcome and Introductions**
The Moderator welcomes the participants in-person and calls the meeting to order, and covers its purpose. The collaborative work by the meeting's sponsors will be recognized. Participants will be briefed on the facilities available at the CaFCP, the schedule of events, meeting procedures, and materials. Participants will be invited to provide their name, affiliation, and state their specific area of interest in the work to develop hydrogen measurement standards.

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(2) Administrative Business

The USNWG will discuss and decide on procedures for managing and documenting its technical work. The following items will be addressed:

(a) Approve the Summary of the October 2007 USNWG Meeting

(b) Approve the USNWG Guidelines

(c) Elect a USNWG Chairperson

10:30 - 10:45 Break – coffee, tea, juice, and pastries

12:15 - 1:30 Lunch – On your own. Invitational travelers should see NIST representatives for transportation.

1:30 - 3:00 (3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement

The USNWG will work within an existing network of experts in the weights and measures and hydrogen communities and promote the establishment of new work groups necessary to develop a set of standards that are appropriate for commercial hydrogen measurements. The commercial hydrogen measurement standards necessary to support the hydrogen economy encompass: (1) device and related equipment codes, (2) method of sale requirements, (3) labeling requirements, (4) fuel quality standards, (5) sampling procedures, (6) inspection procedures, test equipment standards, and safety practices, (7) training for officials and service companies, and (8) education of the public on hydrogen measurement. The USNWG will resume its work on Draft 2.1 of the NIST H44 Hydrogen Gas Meters Code and address any new issues.

3:00 - 3:15 Break – coffee, tea, soda, and pastries

3:15 - 5:00 (3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement (Continued)

Meeting adjourns and reconvenes March 5 at 8:30 a.m. (PT)



AGENDA – DAY 2

DEVICE STANDARDS AND TEST PROCEDURES MEETING

Wednesday, March 5, 2008, 8:30 a.m. – 5:00 p.m. (PT)

California Fuel Cell Partnership, 3300 Industrial Blvd., Dr. Lloyd Conference Room

West Sacramento, CA 95691

Moderator – Juana Williams

- 8:30 - 9:45 **(3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement (Continued)**
- 9:45 - 10:00 Break - coffee, tea, juice, and pastries
- 10:00 - 12:00 **California Fuel Cell Partnership Station Tour**
- 12:15 - 1:30 Lunch – On your own. Invitational travelers should see NIST representatives for transportation.
- 1:30 - 3:00 **(3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement (Continued)**
- 3:00 - 3:15 Break – coffee, tea, soda, and pastries
- 3:15 - 4:15 **(3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement (Continued)**
- 4:15 - 4:45 **(4) Next Steps/Tasks**
The USNWG will discuss ideas for how the work should progress to develop hydrogen measurement standards and its work will be summarized. Project work and target dates will also be identified.
- 4:45 - 5:00 **(5) Next Meeting**
At the conclusion of the March 5 meeting the USNWG will have a better understanding of the work ahead to develop hydrogen measurement standards. Much of the ground work can be completed by conference calls and email. However, three additional work group meetings are tentatively planned for May, and August 2008, and the fifth is to be determined. It is anticipated that there may be a need to dedicate an entire meeting to one specific standards' related project that is identified by the USNWG. Future meeting locations will be based on logistics and technical tasks that the USNWG must accomplish.

Meeting Adjourned

AGENDA – DAY 3

FUEL SPECIFICATIONS SUBCOMMITTEE MEETING

Thursday March 6, 2008, 8:30 a.m. – 12 noon (PT)

California Fuel Cell Partnership, 3300 Industrial Blvd., Dr. Lloyd Conference Room
West Sacramento, CA 95691

Moderator – Kenneth Butcher (NIST)

NOTE: Agenda Items (3) through (7) are the minimum topics that the Subcommittee should consider to address weights and measures hydrogen fuel laws and regulation. Proposals are provided to facilitate and focus the subcommittee's discussion on language that is recommended for NIST Handbook 130 “Uniform Laws and Regulations in the Areas of Legal Metrology and Engine Fuel Quality” or other related publications.

8:30 - 9:00 **(1) Welcome and Introductions**

The Moderator welcomes the participants and calls the meeting to order, and covers its purpose. The collaborative work by the meeting's sponsors will be recognized. Participants will be briefed on the facilities available at the CaFCP, the schedule of events, meeting administrative procedures, and materials. Participants will be invited to provide their name, affiliation, and state their specific area of interest in the work to develop a hydrogen fuel specification. Administrative procedures will include electing a Subcommittee Chairperson.

(2) Background and History Typically, motor-fuel quality standards are developed by standards bodies other than those working directly with the weights and measures community. The weights and measures community may have members participating in the work of those Standards and Code Developing Organizations. The USNWG will not change that process nor develop the fuel quality standard, but will eventually recommend a quality and other related weights and measures laws (definitions, specifications, and method of sale) that should be included in NIST Handbook 130. NIST Handbook 130 is a compilation of the latest uniform standards, related interpretations, and guidelines in the areas of legal metrology and engine fuel quality. States may choose to adopt Handbook 130 as law and regulation. States then establish and administer programs that monitor and enforce method of sale and fuel specification laws.

Work is under way within the global hydrogen community to establish fuel specifications, sampling procedures, and identify test equipment to determine acceptable levels of contaminants, other elements, and particulates for hydrogen refueling applications. The Subcommittee will discuss the status of ongoing work by the International Organization for Standardization (ISO) Technical Committee 197 Working Group 12, California Department of Food and Agriculture Division of Measurement Standards (DMS) (see Attachment 8), and SAE under its Standard J2719 to develop hydrogen fuel specifications. Research is ongoing to determine if it is feasible for products to meet projected specifications and to ascertain if laboratories are capable of making measurements to proposed standards. The Subcommittee is interested in data analysis on contaminant sources such as the environment, motor-fuel dispensing system, sampling methods/equipment, and/or feedstock.

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The USNWG is recommending an approach that sets the limits for hydrogen fuel purity on a percentage basis (for example, 99.999 %, 99.99 %, 99.97 %, or 99.9 % hydrogen). In its October 2007 meeting, the USNWG discussed the allowable limits for hydrogen purity and its effects on the accuracy of refueling equipment when measurements are influenced by a product's molecular weight. The USNWG agreed that impurities up to 0.03 % would not have a significant affect on measurement accuracy. Therefore, the USNWG agreed that products having a percentage value of 99.97 % for hydrogen would be acceptable.

(3) Method of Sale for Hydrogen Dispensing Applications

The Subcommittee is asked to consider proposals to amend NIST Handbook 130 to recognize hydrogen refueling applications to address the method of sale, define what products fall under this application, and device labeling for hydrogen dispensers. The Subcommittee may also wish to consider whether or not requirements are necessary to address prohibited practices (such as unit pricing in decimal cents (e.g., \$3.499 per kg)).

In October 2007, the USNWG agreed that the method of sale for “hydrogen fuel” for retail deliveries (device measurements made for the purpose of sale to the end user) should be made on the basis of mass with the kilogram being the only accepted unit of measurement. The USNWG agreed that hydrogen is metered in mass units of the kilogram which has an energy value similar to that of a gallon of gasoline. Consequently, the kilogram becomes acceptable from a metrological and consumer standpoint.

The first proposal would modify NIST Handbook 130 Section IV. Uniform Regulations Part B. Uniform Regulations for the Method of Sale of Commodities Section 2 Non-food Products. The proposal would include a definition for "hydrogen fuel" that is taken from language developed by the California Division of Measurement Standards. The proposed language is worded similarly to current NIST Handbook 130 text which addresses corresponding requirements for compressed natural gas dispensers and reads as follows:

2.XX. Retail Sales of Hydrogen Fuel.

2.XX.1. Definition.

2.XX.1.1. Hydrogen Fuel. - Means a fuel composed of the chemical hydrogen intended for consumption in an internal combustion engine or fuel cell.

2.XX.2. Method of Retail Sale and Dispenser Labeling.

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2.XX.2.1. Method of Retail Sale. - All hydrogen fuel kept, offered, or exposed for sale and sold at retail shall be in terms of the kilogram.

2.XX.2.2. Dispenser Labeling. - All retail hydrogen fuel dispensers shall display the unit price in terms of price per kilogram.

2.XX.2.3. Street Sign Prices and Advertisements. – When the unit price of hydrogen fuel is shown on street signs and or in any advertisement it shall be in terms of price per kilogram (e.g., “\$3.49 per kg”.

Although a definition for hydrogen fuel is proposed for the method of sale requirements a corresponding definitions is also proposed for NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 1. Definitions to include a definition for the term hydrogen fuel that reads as follows:

1.XX. Hydrogen fuel means a fuel composed of the chemical hydrogen intended for consumption in an internal combustion engine or fuel cell.

10:30 - 10:45 Break – coffee, tea, juice, and pastries

10:45 - 12:15 **(4) Engine Fuel Quality**

The Subcommittee will discuss the best approach for determining which is the appropriate hydrogen fuel quality standard to cite in NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 2. Standard Fuel Specifications. Section 3. Classification and Method of Sale of Petroleum Products may need to be amended to recognize nonpetroleum products and specify allowable terms and abbreviations for identifying hydrogen fuel and the pressures for dispenser applications.

(5) Accurate Measurement of Water Vapor Concentration

This topic directly effects the determinations of the hydrogen fuel purity (99.999, 99.99, 99.97, or 99.9 %) and of hydrogen fuel density. Water vapor is considered one of the most significant contaminants included in hydrogen fuel specifications. In the current ISO TC197 and SAE J2719 standards, it is specified as 5 PPM by volume. This water vapor concentration corresponds to a frost-point of -65.6 °C at one atmospheric pressure with a hydrogen gas density of 0.00531 grams per cubic meter in which the density of water vapor is 0.00520 grams per meter and the density of hydrogen is 0.00011 grams per cubic meter. Therefore, the Subcommittee

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needs to carefully consider the use of hydrogen fuel density in metering.

This topic is involved with the expanded uncertainty ($k=2$) in water vapor concentration for hydrogen fuel specifications, which is proportional to the square root of the sum of relative standard uncertainties of the enhancement factor, the total pressure, and the saturation water vapor pressure. The uncertainty in the enhancement factor is directly proportional to the uncertainty in the second virial coefficient for water, with hydrogen representing the interaction between water molecules and hydrogen molecules. High accuracy second virial coefficient for hydrogen-water mixture has recently become available (see Peter Huang, “Thermodynamic Properties of Hydrogen-Water Vapor and Air-Water Vapor Mixture in Fuel Cells,” ECS Trans. 5, (1) 613 (2007)).

1:30 - 3:00

(6) Laboratory Manual

The Subcommittee will discuss ongoing work to ensure fuel quality laboratories perform measurements that are traceable to recognized national standards. The Subcommittee will work to promote the establishment of documented laboratory practices and procedures that encompass:

- (a) Test Methods and Reproducibility Limits
- (b) Equipment (minimum and recommended) Source and Cost
- (c) Documentation (e.g., Standard Operating Procedures)
- (d) Handling and Storage of Hydrogen Fuel
- (e) References and Good Laboratory Practices
- (f) Minimum Training Standards for Laboratory Personnel
- (g) Facilities
- (h) Safety

(7) Field Sampling Procedures

The USNWG anticipates there are two separate tests that will need to be performed by weights and measures/fuel quality officials. The first is an accuracy test of the dispenser system and the second is sampling hydrogen for compliance with quality specifications.

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The Subcommittee may wish to consider work to establish field sample procedures to provide uniform inspection, sampling, and enforcement procedures to promote the protection of consumers (vehicles) and businesses from economic loss resulting from substandard product and to encourage safe practices by officials conducting inspections. It is recommended that these procedures/guidelines address:

- (a) Equipment/Source/Cost
- (b) Good Sampling Practice
- (c) Handling, storage, and transportation
- (d) Minimum Training Standards for Field Officials

11:00 - 11:45 **(8) Next Steps**

The Subcommittee may wish to consider how future work should progress to ascertain the appropriate hydrogen fuel quality standards. Project work and target dates will also be identified.

11:45 - 12:00 **(9) Next Meeting**

At the conclusion of this meeting the Subcommittee will have a better understanding of the work ahead to develop fuel quality sampling and test procedures for hydrogen used to refuel internal combustion engines and fuel cell vehicles. Some of the ground work might be accomplished through conference calls and email. Future meetings are tentatively planned for May and August 2008, and the fifth is to be determined. It is anticipated that part of the work over the next several months will be to locate individuals who are available and suited to the tasks established by the Subcommittee. Future meeting locations will be based on logistics and the technical needs outlined by the Subcommittee.

Meeting adjourned

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